Let's use models in a more reasonable way ! [1]

by
Guy Landrieu
Institut National de l'Environnement Industriel et des Risques

The total cost of implementation of the J1 scenario for EU-15 has been estimated to 64 milliard EURO/year in 2010 by IIASA. To realize the magnitude of that number : the GNP of EU-15 was estimated to 7580 milliards US $ in 1995. So, without considering detailed bases of such evaluations, the total cost of the J1 scenario is in a order of magnitude near to 1% of GNP, or near to the European Union budget...

The allocation of efforts and financial burden between european countries is a matter of concern. Such an allocation should aim not only at economic efficiency but also at equity. It should not be only a game of chance even chance can sometimes take the form of random result of a model.

1 Models as simulation tools : helping to visualize the stakes of transboundary pollution policies.

During the two last decades, integrated models like RAINS, ASAM, CASM... have been developed in the background of the discussions of past CLRTAP protocols. These models constitute rich but complex tools and questions are being posed about their use.

1.1 The contribution of models for enlightening negotiations

The most important contribution of these models has been a pedagogical one. They have helped people to think about various angles of the transboundary air pollution problem. They have given a language for discussing and visualized links between different aspects in a coherent scheme : listing of possible reductions measures of pollutants emissions and evaluation of their costs, relationship between emission reductions and pollutants concentrations and deposition in Europe in the form of source-receptors matrices, definition of criteria for protecting the ecosystems and potential benefits of action...

The first quantitative use of such models has been as simulation tools in relatively « simple » cases : for example, for a given strategy of reducing SO2 emissions, the

[1] Paper prepared for the UNECE Task Force on Integrated Assessment Modelling, 23rd meeting, Les Diablerets 10-12 March 1999.

model calculate the value of an indicator of potential benefits for ecosystems protection against acidification. Such exercises have been very valuable.

By the development of the sole RAINS model, the same approach is now extended to describing a system taking into account several pollutants (NOx, VOC, NH3, SO2) and several effects (acidification, eutrophication, risks for human health and vegetation resulting from ozone exposure).

1.2 The shortcomings of present models

In the new developments of RAINS model, on one hand the posed problem is more complex and in the other hand stakes are higher. Negotiators and other users of the model should be very careful that such a model, though it represents a lot of work and offer an impressive presentation of results, is only a crude representation of reality.

On some importants aspects of the models, there is a chance that the representation deviates significantly from the reality. As examples, one can mention :

- the evaluation of the potential for emission reductions in the future and the corresponding costs : RAINS considers a given economic scenario for each country, with known levels of production or fuel input and fixed technical processes, and evaluates the potential for « end of pipe » emission reduction for each sector of economic activity. Some studies have been made according to a methodology similar to the IIASA approach but with a more detailed analysis of industrial conditions ([2]). They conclude that potential for emission reduction are lower than RAINS hypotheses, and that reduction costs increase more rapidly when emissions decrease. On the contrary Finn R. Forsund ([3]) remarks that the actual potential for emission reduction is much higher than considered in RAINS, and costs of reduction lower, if one take into account possibilities of input substitution, technological change, and variations in the level of polluting activities that are finally induced by the costs of emission regulations. IFARE studies show that the final result of such effects on costs curves depends a lot on the specific conditions of each country([4]).

---

[2] cf. AEA, Review of IIASA cost curves for the reduction of emissions of nitrogen oxides, sulphur dioxide, ammonia and volatile organic compounds, May 1998.
The AEA study make an estimation of the « incompressible levels of emission » (MFRs) in U.K.. It gives MFRs figures higher than RAINS evaluations, with differences in the order of 40% for NOx, 60% for VOC and 350% for SO2.

[3] F. R. Forsund, Linking RAINS to the economy, Task Force on economic Aspects of Abatement Strategies, 14th session, London 2-4 December 1998.

[4] O. Rentz, et al., SO2 emissions reductions strategies based on the concept of critical load ; analysis and improvement of the RAINS integrated assessment model - applied to the case of France, IFARE, 1992.

- the relationship between variations of emissions in one country and variations of pollutants concentrations or depositions in one grid cell (source-receptor matrices) ; as far as we know, no confidence interval has been yet associated to the coefficients of such matrices ; the uncertainty on estimations should be particularly large for NOx/VOC precursors emissions - ozone AOT60 relationship ([5]).

- the level of pollutant deposition that constitutes the actual « critical load » : critical loads relative to acidification can be calculated according to various approach giving significantly different results ; in particular scientists have suggested that actual critical loads for acidification in some regions could be lower than the present figures taken into account in RAINS. On another side, if the noxious effect on some ecosystems of high load of nutrient nitrogen is clear, the impact of more moderate loads, typical of a large part of Europe is difficult to establish and the value of eutrophication critical loads seems controversed.

The result of these uncertainties is that models should be used only for giving general guidance or global evaluation of abatement strategies. The actual significance of results should not be overestimated. In particular, in the absence of in-depth study, one can think that the confidence given to the results should generally diminish when passing from a general view to the details, in particular when considering results at a fine geographical level.

2. Methodological flaw of using a model as an « optimisation » tool in the present context

As simulation tools, given the pollutants emissions, the models calculate costs and indicators of impacts. Theoretically, models can also be used in a backward mode calculating what should be emissions for achieving fixed targets in terms of impacts or costs. As it can exist in fact an infinite number of solutions to such a problem, generally one may specify additional objectives for arriving at a « best » solution. During such an exercise, models are used as « optimisation » tools.

Developing the optimisation mode of a model like RAINS is a very exciting challenge from a theoretical point of view and by the mobilization of intelligence ressources of mathematicians and computers scientists.

---

[5] cf. EMEP/MSC-W Report July 1998, Calculations of tropospheric ozone and comparison :
Chapter I, Multi-annual comparison of the EMEP lagrangian oxidant model results with ozone measurements. For AOT60... *« it is encouraging that the EMEP results are again generally within a factor of two for these sites »* (p. 19).
Chapter III, Comparison of lagrangian and eulerian models for the summer of 1996 : *« The main difference appears in the France/Germany region, with the eulerian model predicting much more AOT60 than the lagrangian model »* (p. 62).
Such comparisons concern AOT60 values in one grid cell and certainly uncertainties concerning country to grid cell coefficients are relatively higher.

But from a practical point of view, the optimisation mode poses even further the question of the credibility of the results compared to the simulation mode. This is a serious problem because results include, in particular, the allocation of emission threshold between countries, an allocation that has important economic implications.

In addition to the fundamental issue of uncertainty affecting results, there are other questions concerning some choice of modelisation.

2.1 Uncertainty affecting the results and mathematical data processing

In the simulation mode, emissions reductions being given, the user can judge the significance of calculated costs if he has read AEA or IFARE studies ; he can also have an idea about credibility of the evaluation of effects if he has seen comparisons of EMEP models with observations and if he has listened discussions about critical loads.

But in the optimisation mode, all the data is handled in a complex way that is totally opaque for the end-user. In some cases, because of a sort of mathematical lever effect, a small change in the input can have drastic effect on the results ([6]). Even if the model user knows uncertainties affecting input data, his intuition can't be of very much help for understanding the significance of numbers presented as output results of the model.

From the above-mentioned uncertainties affecting input, one can only presume that output like « optimal » allocation of emissions between countries have a high level of uncertainty, or in other words that such allocation be less a requirement for environmental and economic efficiency than an effect of random choices in the building of the model.

Therefore from a scientific point of view one should not recommend an operational use of RAINS optimisation results before an in-depth evaluation of the credibility of such results. This is a point that should comes under a quality assurance / quality control chapter ([7]) ([8]).

---

[6] cf. E. P. Weijers, A review of the RAINS Integrated Assessment Modelling, KEMA, May 1998.
This paper examines the RAINS acidification model in the optimisation mode. It points out for example that a variation of 5% in one input data - the acidification critical load of the 20/17 cell of the EMEP grid - can change of 34% an important output result of the optimisation : the 2010 implementation cost that should be beared by the U. K.. For a better appreciation of the significance of that observation, one can notice that the maximum critical load for Sulphur for that grid cell was estimated to 120 eq/ha/an in the 1995 CCE Report and was in the class 200-400 eq/ha/an in the 1997 Report.

[7] Leen Hordijk - past chairman of the TFIAM, Integrated assessment models as a basis for air pollution negociations, Proceedings from the 5th International Conference on Acidic deposition : Science and Policy, Göteborg, 1995 (Kluwer, 1996)

The fragility of such modelisation inferences is thrown into relief when considering the prudence of some EMEP remarks ([12]).

An alternative approach to the 2010 optimisation should consider the 2010 emissions ceilings as halfway marks towards 2020 or 2030 targets.

3. For a pragmatic approach

Models like RAINS, used in a simulation mode, are indispensible tools for illustrating the relationship between efforts made for reducing pollutant emissions and environmental benefits. In view of the uncertainties of such representations, it would be desirable that the development of others models with different methodological choices should be continued.

The use of such models in an optimisation mode is quite a different question altogether. Such a practice should be considered more as a research exercise than for his direct operational use. To base decisions having important consequences on the output of a black box would give a technocratic image of environmental policies because : 1) maybe nobody except for a few experts understand in-depth his reactions, 2) some displayed principle are highly questionable, 3) input data are obviously very uncertain.

On the contrary of static models, the real world is evolving continuously. The relative importance of various industries change, new technologies emerge, activities move, human behaviour is transformed... It is therefore not possible to confine the future in any definitive model whatever. A pragmatic and efficient approach to manage environmental change is probably an iterative one, with not too sophisticated prospective analyses but frequent re-examination of prospects and possibilities of new improvements.

Presently the reference scenario (REF) constitutes the first basis of work. However a sort of audit would be very useful for verifying that all countries put really the same content in some words such as « business as usual ». The variations of reference emissions for some countries in successive interim reports of IIASA study is posing a question.

---

[12] cf. D. Simpson and A. Eliassen, ibid.,:
« Even the current authors admit that it is possibly dangerous to rely on the results of the EMEP model (any model) to be correct for the year 2010 when emission reductions of order of 80% are being considered ! Thus, the possibility exists that features such as the ozone 'hill' discussed above may be artifacts, due to unavoidable uncertainties connected with, for example, biogenic or man-made emissions, model formulation, or even basic scientific understanding. Thus a global optimisation which relies upon the model results to be accurate at all extremes of its prediction may give a worse answer than a simpler iterative approach which proceeds in small steps with an emphasis on safe strategies at all emissions levels. »

If countries want to go further in environmental protection, considering the large uncertainty affecting evaluations of benefits and costs of environmental protection measures (as often for problems relating to sustainable development), the first direction of work should be to formulate and study common policies. Such common policies could be based on the implementation of specific technical measures or on general emission reduction commitments, taking into account percentage of reduction with regard of a reference year or level of emission per inhabitant.

However, one can easily understand, and models show, that some regions in the centre of Europe, characterized by high densities of population, activities and pollutant emission and being at the confluence of various pollution flows, may justify particular reduction efforts. Studies could be made, country by country, of the effects in terms of costs and benefits of specific supplementary measures by using simulation models.

The resolution of problems caused by locally high densities of emissions should be searched at first at the local level.

Annexe : Quelques citations rappelées en toile de fond de l'exposé

... it is of major importance
to face the limitations of the model to be built
and to recognize the type of issues/questions
that cannot be adressed by
and what falls beyond the scope of the model.

... Making the uncertainties visible and tangible
is one of the key issues of this research...

J. Rotmans, M.B.A. van Asselt,... H.J.M. de Vries
Global change and sustainable development,
a modelling perspective for the next decade
RIVM, 1994

Although the management of uncertainty
within computer models is not sufficient for the full
assurance of quality in Integrated Environmental Assessments,
it is quite necessary...

Unless there is quality assurance at the quantitative end
of the decision process, then at the qualitative end
there is no protection against all sorts of subjectivity and caprice.

Jerome R. Ravetz
Integrated Environmental Assessment Forum :
developping guidelines for « good practice »
ULYSSES Working Paper, EC Joint Research Centre, 1996

Except when standard well validated engineering design models are being used,
the one thing it is almost never appropriate to do
is to run a big research model
and then adopt its output as policy gospel.

The key point to remember is that without thorough and systematic modeling and
analysis of the uncertainty of the problem,
we can not be sure that the results of a model,
especially a very large and complex one,
mean anything at all.

M. Granger Morgan and Max Henrion
Uncertainty, A Guide to Dealing with Uncertainty
in Quantitative Risk and Policy Analysis,
Cambridge University Press, 1990.